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ABSTRACT

The primary purpose of this study was to examine uneven early development in premature infants. A multiple regression analysis was performed in which birth weight, length of gestation, length of assisted feeding, and length of ventilation were used to predict the descrepancy between a child's Psychomotor and Mental Scale scores on the Bayley Scales of Infant Development (BSID). The child with a large difference score was expected to have been ventilated longer, to have needed more assistance in feeding, to have had a shorter gestation, and a smaller birth weight than the child with a small difference score. The results of the study did not support the hypothesis that a difficult newborn course would be reflected in a discrepancy between mental age and psychomotor age on the BSID. A post-hoc analysis revealed that none of the four variables were predictive of the size of the discrepancy when directionality was considered. Correlation coefficients between the dependent and independent variables were low. (JAZ)

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PREDICTION OF OUT-OF-SEQUENCE DEVELOPMENT BY BSID SCORES

By

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INTRODUCTION AND REVIEW OF THE LITERATURE

Infants born prior to 40 weeks of gestation are at medical risk because of immature anatomical or physiological development. Short gestational periods are associated with low birth weights and with a variety of abnormal outcomes, including birth deficits, hospitalization, and medical interventions. These abnormal conditions may minimize or preclude many beneficial interactions with the environment. With or without detectable damage to the preterm infant, early development may not proceed at the same rate as for the fullterm, healthy infant. There may be an overall delay, or one or more systems may lag behind other systems, resulting in uneven or out-of-sequence development. This study investigated such uneven or out-of-sequence development using a regression analysis and employing transformed scores from the Bayley Scales of Infant Development (BSID). Risk variables associated with prematurity served as predictors of out-of-sequence development.

Prematurity has been hailed as a risk factor affecting subsequent development (Francis-Williams & Davies, 1974). The change from an intrauterine environment to an extrauterine environment is a challenge for an intact infant, but poses additional problems for the immature physiological systems of a preterm infant. As a direct result of continual advances in medical technology, the survival rate of preterm infants is ever-increasing. Considering the number of children surviving with the prematurity risk factor, early identification of infants at risk for developmental delays is becoming a pressing need (Ross, 1985; Siegel et al., 1982).

The most common complication among preterm infants is respiratory distress syndrome (RDS), a disorder marked by immature lungs and delayed onset of breathing (Thomas, 1977). Surfactants, substances which facilitate the exchange of oxygen and other gases in the alveoli, are not usually produced by the lungs prior to full term. With a lack of oxygen, neurological damage may occur in varying degrees. Therefore, RDS usually requires the administration of various percentages and pressures of oxygen by means of mechanical ventilation, with subsequent weaning to room air. In the neonate, the need for assistance in respiration would seem to indicate significant impairment. A long range study of preterm and fullterm infants revealed that severity of RDS is an important predictor of cognitive, motor, and language development (Siegal et al, 1982).

In addition to RDS, the inability of a child to feed appropriately can be considered a high-risk factor. In a personal communication, a prominent neonatologist, Dr. Gene Gates (1985), stated that infants who feed poorly have less satisfactory prognoses than do infants without feeding difficulties. A research study of the feeding behavior of three-day-old fullterm infants disclosed clear differences between optimal and non-optimal sucking behavior (Rybski & Gisel, 1984). The authors suggest that the addition of a measure of sucking behavior to standard neurological testing might better differentiate intact from damaged infants.

Length of gestation is a significant predictor of development among preterm infants. In a study of 510 preterm infants, short periods of gestation were associated with problems in central nervous system development (Aylward, Hatcher, Leavitt, Rao, Bauer, Brennan & Gustafson, 1984). The authors concluded that since length of

gestation has such an impact on behavior, it is unwise to treat preterm infants with widely varying gestational periods as a homogeneous sample.

Although length of gestation and birthweight are highly correlated, birthweight may be the more reliable measure of neonate maturity. The determination of length of gestation is usually made with a rather arbitrary rating scale requiring some degree of subjective judgment by the physician. Birthweight, on the other hand, is highly objective.

The BSID is widely acclaimed as one of the best available measures of infant development, but its adequacy as a tool for assessing minor degrees of disability, such as muscle tone abnormalities, is seriously questioned (Sheehan, 1982). While the majority of children born prior to term develop within normal limits (Astbury et al, 1983; Paludetto et al, 1982; Silva, McGee, & Williams, 1984), there is a growing body of research demonstrating that their development differs subtly but significantly from that of fullterm infants (Bloch, 1983; Ferrari et al, 1983; Niparko, 1982; Ross, 1985). Ferrari et al (1983) examined the performance of preterm healthy infants at expected dates of delivery and found that the behavioral repertoire of preterm infants was more heterogeneous and poorer than that of fullterm subjects. A number of long-range studies have reported that at-risk infants classified as within normal limits at their initial evaluations were classified as deficient on follow-up examinations (Astbury, Orgill, Bajuk, & Yu, 1983; Bloch, 1983; Ferrari, Grosoli, Fontana, & Cavazzuti, 1983; Harmant, Roucoux, Culee, & Lyon, 1983; Jacob, Benedict, Roach, & Blackledge, 1984; Paludetto et al, 1982). It is not known if these deficiencies surfaced after the

initial evaluations, or if the BSID was insensitive to subtle deficiencies in quality of performance in at-risk infants.

Not only do birth deficits, anoxia, and their resulting complications interfere with the growth and development of the preterm child, but so may necessary interventions such as assisted respiration (ventilation) or assisted feeding. For example, retrolintal fibroplasia may result from hyperoxygenation during ventilation rather than from anoxia. More subtle damage may occur as a consequence of the method employed in assisted feeding. Such methods include hyperalimentation, nasal tube feeding, and gastrostomies.

Since muscle tone influences the acquisition of developmental milestones, it should be considered in developmental evaluations (Scherzer & Tscharnuter, 1982). In some cases, the presence of abnormal muscle tone results in paradoxical evaluations on the BSID with passing scores reflecting inadequate development. For example, consider a child born 3 months prior to term with a current chronological age of 6.5 months. His adjusted chronological age would be 3.5 months, the age he would have been had he been born at full term. This child might pass a head control item at the 4 month level and fail an item at the 3 month level which required the hands to be opened more often than closed. Success on the 4-month item might be due to the predominance of extensor tone over flexor tone in his truck and neck, and failure on the 3-month item might be due to abnormal persistence of upper-extremity flexor tone. The presence of abnormal muscle tone would therefore result in a Psychomotor Age Equivalent of 3.5, the child's adjusted chronological age. Thus a child would be evaluated as being on target developmentally in spite of the fact that his development is compromised by abnormal muscle

tone. Stone (1983) found evidence for such paradoxical evaluations with the BSID. She discovered an inverse relationship between normal development and passing scores on some psychomotor items at certain levels of development.

Similar misclassifications can arise on the Mental Scale of the BSID. For example, a child may be very social and receive credit for high level items involving interactions with adults but be unable to focus his attention on objects, or he may lack muscle tone needed for swiping at objects, skills required by many lower level items.

Inherent in any pass-or-fail test item is the possibility of credit being given even though the performance was not executed with purpose, quality, or ease. The result is inflated test scores which may cause parents to overlook slight problem areas they might otherwise notice. Intervention may then be delayed until the problem can no longer go unattended, making therapeutic intervention less effective. This travesty can hardly be considered a fault of the examiner since the criterion was met for each test item passed. The fault lies in the difficulty of summarizing into a single index the often heterogeneous behavior repertoire of the preterm child.

In contrast to the BSID, a therapist's evaluation of an infant's development would include thorough periodic examinations of the <u>quality</u> of his movements and of his muscle tone and a log of the presence or absence of each of the primitive reflexes. Also, discrepancies within or among the various areas of development would be noted. Consider a child who has developed head control in some positions but not in others, or one who rolls but lacks head control, or crawls but does not exhibit protective extension in sitting. Such out-of-sequence progressions, as well as any abnormal muscle tone or

reflex development, would be of concern to the therapist and indicate the possibility that development is not progressing normally.

While BSID scores can yield an inaccurate picture of a child, useful information may perhaps be gleaned by score transformations or derivations. In keeping with the therapist's viewpoint, it is asserted that uneven development, whether imbalances in muscle tone (such as stronger extensor than flexor tone), delayed emergence or persistence of primitive reflexes, or a lack of quality in performances, would be reflected by discrepancy between Mental and Psychomotor Scale scores. This study attempted to predict out-of-sequence development from variables known to be or suspected of being predictors of abnormal development. Out-of-sequence development was measured as the absolute difference between Mental Age and Psychomotor Age on the BSID. A child whose two scale scores are the same or nearly the same would seem to have a more normal development sequence than would a child with a large discrepancy between the two scale scores. Risk factors to be considered in this study are length of gestation, birthweight, length of ventilation, and length of assisted feeding. These four factors were used to predict the size of a child's difference score, that is the discrepancy between his Mental and Psychomotor scale scores. The child with a short gestation, a low birthweight, and lengthy assistance in ventilation and feeding was expected to have a larger difference score than a child with fewer difficulties in the natal and postnatal periods.

METHOD

Subjects

The subjects were premature infants whose perinatal care included hospitalization in a Neonatal Intensive Care Unit (NICU) in northeast Louisiana and who were evaluated in an infant development center in the same area. Subject selection was made on the following criteria: (a) A gestational age of less than 38 weeks, or (b) a birthweight of less than 2500 grams, and (c) an assessment using the Bayley Scales of Infant Development prior to a chronological age of 6 months. Infants with congenital birth defects or chromosomal abnormalities were excluded from this study.

Instrument

The Bayley Scales of Infant Development (BSID) were used to assess the level of functioning for each subject at approximately three months past expected delivery date. The test is composed of two sets of items which comprise the Mental and Psychomotor Scales. A subject is rated as passing (P) or failing (F) each item with provisions for comments and observations. The Psychomotor Scale measures gross and fine motor skills and provides an average age at which each skill is attained. The Mental Scale broadly assesses language skills, visually directed movements, auditory responses, and social interaction. Average ages for attaining these skills are also provided with both scales covering skills from 0.1 to 30+ months. The early intervention center that is the site of much of this study uses the BSID as the primary assessment tool because of the instrument's standardization, reliability, and the broad spectrum of infant behavior which is considered. These attributes made the BSID ideal for the purposes of this study.

Procedure

The files of the infant development center were searched for the names of infants meeting the criteria for subject selection. Records for each of these children were then pulled from the files of the two neonatologists attending the patients of the local NICU. Data were recorded from the files of each subject for the variables under consideration.

RESULTS

Stepwise multiple regression was used to treat the data in order to analyze the relationship between the dependent variable (absolute difference between MA and PA) and the four independent variables. The statistical program was from the SPSSx User's Guide (1983). In its simplest application, multiple regression may be used to determine the amount of variation in the dependent variable that can be explained by the combined operation of the independent variables (Kohout & Kim, 1975). A regression equation is generated in which each variable can be evaluated for its relative contribution in predicting the dependent variable. In the present study, the dependent variable was the absolute difference between MA and PA, and the predictor variables were birthweight, length of gestation, length of assisted feeding and length of ventilation. The analysis failed to yield a significant R value because the limits for the probability (.05) of F for a variable to enter the equation were reached before the first variable entered. Therefore results were uninterpretable. Means and standard deviations for the dependent variables are presented in Table I.

TABLE I

Summary of Data for Difference Scores and Predictor Variables

	Mean	Standard Deviation
Absolute difference scores	.67	.59
Birthweight	2266.32	837.69
Length of gestation	34.32	3.58
Length of ventilation	9.81	18.16
Length of assisted feeding	20.59	21.81

Post hoc analyses were performed to examine the data further and provide insight for further study. In a second multiple regression algebraic difference between MA and PA rather than absolute difference served as the predicted variable. Again, none of the four predictor variables entered into the regression equation.

The correlation matrix shown in Table II is presented for descriptive purposes. In addition to the variables directly in the analysis, it contains MA and PA from which the difference scores were calculated. It also includes the algebraic difference score which served as the predicted variable in the post hoc multiple regression analysis.

TABLE II

Correlation Matrix

	BW	LOG	LOV	LOF	ABSDIF	DIF	PA	MA
BW	1.00							
LOG	.80	1.00						
LOV	-.45	-.62	1.00					
LOF	-.32	-.50	.74	1.00				
ABSDIF	-.08	-.10	-.03	.04	1.00			
DIF	.13	.09	-.06	.13	.01	1.00		
PA	.04	.10	-.02	-.22	-.11	-.46	1.00	
MA	.15	.18	-.07	-.12	-.11	.33	.69	1.00

BW=Birthweight scores
LOG=Length of gestation
LOV=Length of ventilation
LOF=Length of assisted feeding
ABSDIF=Absolute difference
DIF=Algebraic difference scores
PA=Psychomotor age
MA=Mental age

DISCUSSION

The primary purpose of this study was to examine uneven early development in preterm children. To achieve this purpose a multiple regression analysis was performed in which birthweight, length of gestation, length of assisted feeding, and length of ventilation were used to predict the discrepancy between a child's Psychomotor and Mental Scale scores on the Bayley Scales of Infant Development (BSID). The child with a large difference score was expected to have been ventilated longer, to have needed more assistance in feeding, to have had a shorter gestation and a smaller birthweight than was the child with a small difference score.

The results of the study did not support the hypothesis that a difficult newborn course would be reflected in a discrepancy between MA and PA on the BSID. None of the four predictor variables (birthweight, length of gestation, length of ventilation, and length of assisted feeding) were statistically significant predictors of the absolute size of the discrepancy. A post-hoc analysis revealed that none of the four variables were predictive of the size of the discrepancy when directionality was considered.

Correlation coefficients between the dependent and independent variables were low. Failure to find correlations between the difference scores and the independent variables results in a lack of support for the hypothesis of this study. Failure to find correlations between MA or PA and the independent variables leads to the examination of two possibilities. Either the independent variables do not influence development, or the BSID is insensitive to that influence. The first possibility seems unfeasible considering research describing the significant differences between the ability and performance of preterm and fullterm children. More likely, the nature of pass-fail test items coupled with the subjective criterion specified for passing each BSID test item results in inaccurate assessments of development when administered to preterm at-risk infants prior to six months of adjusted chronological age. This is not to say that infant assessment should be postponed until later when BSID scores are perhaps more informative. Jeopardized development, whatever the etiology, should be detected as early as possible and remediation begun immediately. Abnormal muscle tone or patterns of movement can become stronger and more pronounced without intervention. Damaging compensatory mechanisms may also be devised by the infant and

they are much easier to prevent than to alleviate. Detection of problems must be attempted early. In working with preterm infants it has been the author's impression that in the first six to nine months their development is not so much delayed as "out of sinque"--either one or more areas of development are ahead of others, or there is a lack of quality, purpose or ease in execution of tasks. Perhaps the pooled observations of infant evaluators, pediatric therapists, neonatologists, and pediatric nurses would yield a more accurate, though not quantified, assessment of an at-risk infant. Although difficult and time consuming, a meeting of the minds of such professionals with a goal of quantifying their observations and intuitions concerning preterm infants would be well worth the invested time and effort. A scale or assessment tool derived in this manner would certainly tap the subtle differences between preterm and fullterm infants and begin to differentiate levels of slight disability at a very early age. It may be possible to recognize these subtle differences by use of the BSID, but not as the scores are currently interpreted.

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